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ISSN: 2473-5132 (Print) 2473-5140 (Online) Journal homepage: http://www.tandfonline.com/loi/rfdh20

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To cite this article: Sophie Crocker & David Leatherbarrow (2018): The closed loop: ninety years of health care architecture, Design for Health, DOI: 10.1080/24735132.2018.1447181

To link to this article: https://doi.org/10.1080/24735132.2018.1447181

DESIGN FOR HEALTH, 2018
https://doi.org/10.1080/24735132.2018.1447181

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The closed loop: ninety years of health care architecture

Sophie Crocker and David Leatherbarrow

PennDesign, University of Pennsylvania, Philadelphia, PA, USA

ABSTRACT

This article considers how the perceptions of health care architecture and the health care Architect have changed over the past 90 years. Four case studies (Alvar Aalto's Paimio Sanatorium, Finland; Peter Womersley's Nuffield Transplantation Unit, Scotland; and two outpatient cancer treatment centres by EwingCole for Memorial Sloan-Kettering, USA), distributed between 1928 and 2014, are used to explore the shifting status of architecture in the medical setting. The twentieth century was a period of rapid medical advancement; improvements in life expectancy and treatments for previously incurable conditions progressed faster than ever before. During this time, health facilities became ever more crowded with medical technologies, which swiftly outstripped architecture in perceived value and importance in the healing process. Today the tides are turning for the weight given to architecture in health care settings; however, acknowledgement of the physical and psychological impact of architecture on the human body is yet to permeate all sectors.

ARTICLE HISTORY
Received 6 February 2018
Accepted 23 February 2018

KEYWORDS
Aalto; Womersley; EwingCole; biophilic; health care design; history

Introduction

How can we successfully and considerately press forward with health care design innovations without fully comprehending the history of health care design theories and devices and how they have influenced contemporary medical architecture? This article presents the 'closed loop' of the last 90 years of health care design. Using case studies of significant medical architecture, with primary source evidence where possible, it paints the picture of a fascinating cycle in health care design over almost a century of medical progress through providing an understanding of the contemporary condition for the design of the projects, the thoughts and beliefs of the architects in charge, and how the buildings were received by the contemporary press. Connecting four works of health care architecture and delineating their consistencies, contradictions and evolutions through the time period provides a unique perspective on the status of

CONTACT Sophie Crocker s.crocker@hotmail.com, sophiecrocker@alumni.upenn.edu

twenty-first-century health care architecture in relation to the efforts made by our twentieth-century counterparts.

The four case studies used to track this cycle were chosen owing to their status as revolutionary buildings for the care of people suffering from a specific illness or to house a particular process; tuberculosis – Alvar Aalto's Paimio Sanatorium in Finland; organ transplantation – Peter Womersley's Nuffield Transplant Unit in Scotland; and Cancer – EwingCole's Memorial Sloan-Kettering (MSK) Cancer Centers in West Harrison, NY (MSKWH) and Basking Ridge, NJ (MSKBR), United States. These projects also share local climate conditions and are roughly evenly spread through the 90-year period in question. It is important to note the two twentieth-century examples are both public buildings, partly or entirely funded by government, while the twenty-first-century case studies were commissioned and funded by private enterprise.

The twentieth century was a period of especially rapid medical advancement; life expectancy in the United States increased by twenty years during this period. In 1921, the first tuberculosis vaccine was developed and used successfully on humans (Calmette 1931, 85–94) and the first successful kidney transplant took place in 1954. Throughout this era, hospitals and health centres became ever more crowded with medical technologies, rapidly outstripping the architecture of health care of perceived value in the healing process. The period of study was selected due to the fact that each architect had to grapple with advancements in medical knowledge and/or technologies and respond by designing a facility appropriate to those innovations. Given the extent of medical progress in this period, and its impact on the architecture of health care facilities, it provides fertile ground for investigation.

The commission for a sanatorium in Southwest Finland, which would later be described as 'far ahead of anything the medical profession has yet demanded' (Ehrström, Jetsonen, and Lindh 2005, 28), was awarded to Aalto in 1929. Paimio is an example of early experimentation in Aalto's evolving concepts concerning architecture's ability to positively affect human experience. While the building was not necessarily innovative with regard to the treatment it enabled, it was hailed as the first attempt in Finland to use architecture to implement the treatment of a prevalent disease (Ehrström, Jetsonen, and Lindh 2005, 43).

By the beginning of the twentieth century, the contagious nature of tuberculosis was understood, and the practice of confinement for the infected as both cure and means for controlling the spread of infection was widely used throughout Europe and the United States. A tuberculosis vaccine had been developed with successful results on humans six years prior to the competition for Paimio; however, an article in *The Lancet* (1924, 227) at the time suggests that efforts to advance the treatment of the condition were not progressing as rapidly as prevention. It describes how the treatment of tuberculosis by the routine of fresh air, rest, controlled diet and gentle exercise was so widely implemented that it was difficult to compare it for efficacy with any other regime. Thus, the disease

remained a threat to public health in Finland, as well as most European countries, and Aalto's design for the Sanatorium at Paimio intended to enable the best possible form of the traditional treatment regimen – to make it as efficient and as pleasant for the patients as possible.

After the first successful kidney transplant was performed by Joseph E. Murray and his team in 1954 (U.S. Department of Health and Human Services), it was not long before the operation became a more widely viable solution. In 1963, after the UK's first successful kidney transplant in 1960, the brief for the Nuffield Transplant Unit at Edinburgh's Western General Hospital was given to architect Peter Womersley (1923–1993) (*Architectural Design* 1964, 269). The design and construction of the Unit was funded by the charitable organization, the Nuffield Foundation, while the staffing and running costs were covered by the Scottish Home and Health Department.

The building was the first ever purpose built organ transplant unit and therefore the architect was designing for potential, as well as known, programmatic conditions (Johnston 1968, 156). Everything from the technical specifications to the way the patient would be feeling, psychologically and physiologically, was new. The commissioning of a special transplantation unit at the Edinburgh hospital in 1963 was very progressive and the unit became a model for facilities that were built subsequently.

Although Womersley can by no means be described as a health care architect, he did, importantly, experiment in the field and the Nuffield Unit received high critical acclaim. Within a decade of the completion of Paimio, an article in *The Lancet* declared the 'day of the benevolent amateur' over and called for specialization in hospital construction by both architects and doctors (1941, 737–738). This was due to the understanding that hospitals, and the medical processes and technologies they housed, were becoming increasingly complex. It is interesting therefore, that Womersely – a so called 'benevolent amateur' – gained the commission for this one of a kind, facility.

The first successful kidney transplants were between identical twins to minimize the chances of the body rejecting the new organ. Anti-rejection drugs were not advanced enough to depend upon, and organ recipients were put in states of extreme immunosuppression before transplantation. Dialysis was another new technology; the first artificial kidney was developed in Denmark in 1943; however, the technology did not leave Denmark until after the Second World War and, in 1962, dialysis was introduced to Edinburgh (Farrell 2016). These conditions for organ transplantation resulted in an experimental building that was designed to house just six patients in sterile isolation rooms. The limit on space is one of the reasons for the building becoming redundant in 1995 (Clinical Surgery 2015), compared to Paimio never ceasing to function as a medical facility. The architect and medical professionals were unprepared for organ transplantation to become so (relatively) widely available. The building housed innovative medical processes and is emblematic of medical advances forcing a

shift in emphasis from creating healing environments to the needs of healing technologies and provider efficiency that occurred during the twentieth century.

In 1998, EwingCole received a commission from MSK Cancer Care for its first free-standing centre outside of Manhattan. In an interview conducted by the author in 2016, Andrew Jarvis, Director of EwingCole's Healthcare Practice, pinpointed this commission as the turning point in attitudes to health care architecture during his career. The client asked Jarvis and his team to rethink cancer care and to re-examine all the processes that a patient goes through in order to create a more therapeutic and holistically healing environment.

In the short time between the construction of MSKBR and MSKWH (completed in 2006 and 2014, respectively) developments in the understanding of cancer care altered the way in which space was arranged and divided, advancements in technology enabled the team to implement concepts that they had previously been unable to test, and changes in the ways health care companies are reimbursed put even greater emphasis on patient experience demonstrating the rapid evolution that continues in this century. Therefore, two twenty-first-century case studies are not only necessary to fully analyse how health care design has evolved into its current form but to also understand where it might be headed. The twentieth century was an era of exceptional medical advancement; however, the twenty-first century is set to be equally remarkable. These two facilities, constructed less than a decade apart, already evidence the rapid progress being made in medical architecture.

Jarvis has dedicated his career to health care architecture with a particular concentration on cancer care; he has designed and seen through construction over 25 cancer care buildings over the past 15 years of his career. Therefore, unlike the architects of the two twentieth-century case studies, the MSK projects were designed by a specialist. It is rare today for a 'generalist' such as Aalto or Womersley to design a complex medical facility as they did during their careers. The 1941 calls of the physicians in *The Lancet* have finally been heeded (1941, 737–738).

The two MSK facilities offer many of the same treatment and consultation services while serving different geographic regions around Manhattan. As well as the testing and treatment services provided at MSKBR, MSKWH provides genetic counselling, nutrition advice and acupuncture, demonstrating a move towards a more holistic approach to cancer therapy.

After losing influence in the middle of the twentieth century, evidence supports the general observation that health care design has become more highly valued and received more investment over the past 20 years. Since 1960, the number of studies conducted exploring the impact of hospital design on patient and staff health and wellbeing has risen dramatically. In the first two years of the twenty-first century, there were more studies conducted than in the three decades between 1960 and 1990 combined (Ulrich and Zimring 2005). Another sign that health care architecture is gaining value and respect is the establishment of

institutions and publications on the subject as well as the gradual increase in the number of articles concerning health care design appearing in medical journals.

This article analyses each building within three distinct topics. Each theme for analysis has been selected owing to one or more of the architects stating it as a specific focus or due to the opportunity it affords to delineate a trajectory in shifting perceptions of the health care architect and of the value of architecture in the healing environment. This article connects threads of health care design theory and practice through the course of almost a century of medical progress to tell a more comprehensive story than could be achieved individually.

Nature

The differences in the perceived importance of nature across the case studies is one of the most profound evidences of the 'closed loop' referred to in the title of this article, and represents the shift in attitudes that occurred during the middle of the twentieth century. While access to and views of nature were of utmost importance to Aalto when designing Paimio, they were significantly less valued in Womersley's Nuffield Unit almost 40 years later. Today, EwingCole is one of the many firms working to reassert nature's value in healing environments.

Aalto's views on the importance of nature in the built environment stem from a deep affinity for the Finish landscape and were central to his designs throughout his career (Pelkonen 2009, 43). While he did not always use natural materials, sometimes opting for a modernist aesthetic, he maintained a strict sensitivity to the pre-existing conditions of site and encouraged opportunities of interaction with nature at the human scale (Schildt 1994a, 108). Aalto's concern with nature runs throughout the design for Paimio but stemmed from observed and embodied experiences of interactions with nature rather than a body of research.

Aalto primarily integrated nature in his design for Paimio through the creation of views out toward the surrounding forested hills. Sun balconies (see Figure 1) at the ends of patient floors were designed to maximize the amount of natural light a bedridden patient could experience each day (Anderson 2010), while also enabling the patient to observe the goings on in the grounds of the Sanatorium. Plant boxes on the roof terrace also reveal an effort to provide some contact with nature to those patients who were confined to the building (Figure 2). Aalto chose very functional materials for the project. The floors were covered in colourful rubber while walls were painted different shades of muted greens, creams and whites. However, he rebelled against the cutting-edge steel frame furniture which was commonly used in modernist buildings, believing that it was too cold and hard for the sensibilities of a physiologically weak human being (Ehrström, Jetsonen, and Lindh 2005, 35). He designed wooden framed furniture and included wood finishes in hand rails and door handles (Rybczynski 2015). This attention to the patient's tactile experience was unusual in a health facility of

Figure 1. Paimio patient wing sun balconies (now mostly enclosed) (Liao 2011).

Figure 2. Paimio roof terrace (Godel 2012).

the time. Aalto was extremely progressive in his equal concern for the psychological and physical experiences of a place.

The difference in attitude between Aalto and Womersley was dramatic. Womersley showed little interest in providing access to nature or in using

natural materials. This was by no means entirely representative of the period, however. Womersley's contemporary, Richard Neutra, strongly believed in nature's power to reduce stress and anxiety in patients. His project, the Mariner's Medical Arts Building (1963), demonstrates extensive use of nature throughout a health facility in the 1960s. Womersley, however, was not designing a general practice but the first specifically designed unit for the transplantation of human organs. Pressures of the new technology and medical processes reigned supreme over any residual concerns regarding provisions of contact with nature.

The patient rooms in the Nuffield Unit are separated from the external envelope by a 'dirty' corridor making it difficult for the architect to create views outside from the patient's bed. This was a concern for the architect. Womersley strongly felt that visual contact with the outside world was of the utmost importance for this facility as both patients and staff would be contained inside for hours at a time. For patients, this could extend to weeks. These views were not intended to afford contact with nature, as they were for Aalto, but to provide reassurances that 'everyday life continues normally' (Progressive Architecture 1968, 116) during the period of confinement. Womersley acknowledged that a facility designed to restrict interpersonal contact to such a degree ran the risk of feeling like a prison (Womersley 1969).

Devices Womersley implemented to blur the boundary between interior and exterior appear to be primarily aesthetic. The vaulted ceiling extends beyond the building envelope and attempts to distort distinctions between inside and outside space (Progressive Architecture 1968, 118) while also outwardly exhibiting the sculptural quality of the interior concrete structure (Figure 3). Besides the attention to the programmatic and medical functioning of the facility, Womersley's chief concern seemed to be with experimentation in concrete construction, resulting in many design decisions being made to enhance the display of such material acrobatics. Womersley appeared to give little thought to a patient's tactile environment. Not only were patients restricted from any human physical interaction but they also had no contact with natural materials. It must be noted, however, that natural materials such as wood and stone were significantly more difficult to keep sterile and therefore in an environment such as Nuffield, where asepsis was of utmost importance, this would have justifiably been a factor in Womersley's decision-making. Although, if Womersley gave any thought to a patient's experience, it might be evidenced in brighter, warmer coloured materials and lighting instead of the stark, institutional interior he produced. It can conversely be argued that his use of experimental construction techniques and architectural forms was psychologically beneficial to the patients in their own right; an extremely contemporary building conveyed the notion that an extremely advanced process was contained within, reassuring the patients and family members alike.

In the twenty-first century, including nature in health care architecture is once again at the forefront of design decisions. The presence of nature is a strong

Figure 3. Nuffield unit exterior view (Williams 2018).

common theme between both MSK facilities. For MSKBR, EwingCole made the most of the new build project and designed a curving façade to maximize views out to the forested surroundings (Figure 4). Patients attending the premises are often physically weak and mentally exhausted or overwrought. Therefore, there was an emphasis on providing a familiar, comfortable and non-institutional environment. Special care was taken in the design and layout of the chemotherapy infusion stations in this regard. With insufficient perimeter wall to position every chair beside a window, the team painstakingly arranged the chairs and translucent/transparent glass partitions to ensure that every chair had a line of sight to the outdoors without ever looking directly into another patient's cubicle.

The existing structure at MSKWH, on the other hand, underwent significant alterations to the perimeter and core to afford each private room views outside and to bring natural light and opportunities for planting deeper into the floor plate of the ex-office block (Figures 5 and 6). These efforts echo those made by Aalto in the first quarter of the twentieth century; however, instead of being based on an architect's 'hunch' or his observations regarding the human connection with nature, they are now supported by studies that demonstrate the

Figure 4. Memorial Sloan-Kettering Cancer Care Centre, Basking Ridge (EwingCole 2006).

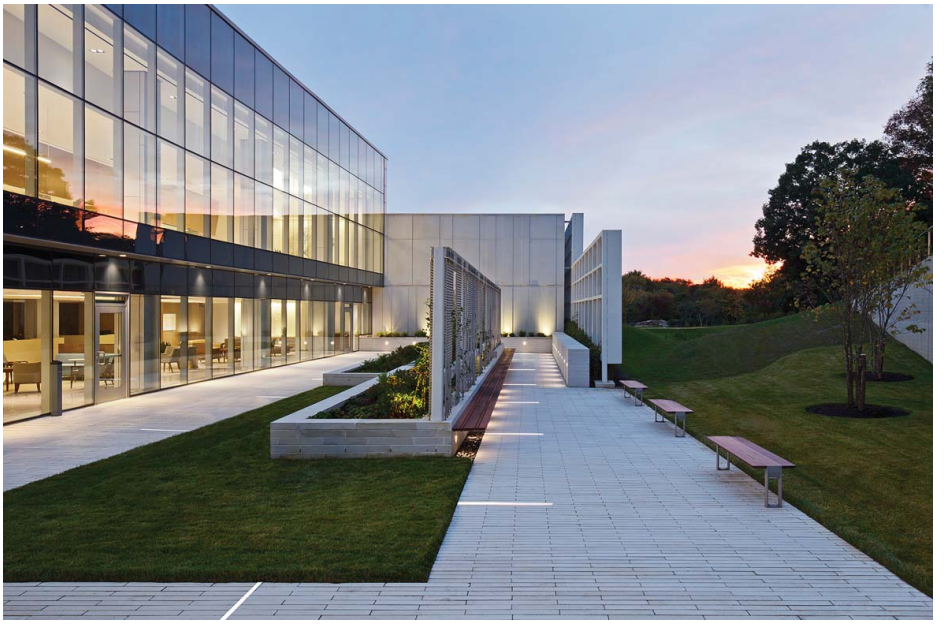

Figure 5. Memorial Sloan-Kettering Cancer Care Center, West Harrison, Courtyard (EwingCole 2014).

Figure 6. Memorial Sloan-Kettering Cancer Care Center, West Harrison, Infusion Room (Ewing-Cole 2014).

correlation between healing rates and views to nature (Ulrich 1984, 420–421). This, in turn, has resulted in a business incentive for the inclusion of nature in health care facilities; the faster a patient heals, the less time and money is spent on them.

While Womersley seemingly acceded to the dominance of the advanced medical technologies and processes his facility housed, Jarvis and his team at EwingCole sought out ways to render the large and extremely intimidating medical technologies and machinery less threatening, often through the use of nature. One architectural device Jarvis used was that of distraction: he contends that by placing something larger than the very large machine in the room, the patient's attention will be diverted, and by infusing that distraction device with natural imagery and materials, it can be calming in itself. This tactic was used for the PET-CT machines and Linear Accelerators in both MSK facilities.

Inclusion of nature was the most essential element of Aalto's philosophy of humane design. It became the strategy that most readily fell by the wayside once an architect was presented with the difficult task of designing for technologically advanced medical practices. Now it has regained its rightful position as a key tool in health care design to promote healing and diminish anxiety; not in spite of medical advances since Aalto and Womersley, but because of them.

Concern for the senses

The architects' considerations for patients' 'entire subtly organized being' (Neutra 1954) when designing the health facilities are emblematic of their

understanding of the psychosomatic effects of the built environment and their views on the importance of architecture during the healing process. While two of the architects, Aalto and Jarvis, carefully and extensively studied the patient's entire sensory experience, Womersley evidenced little concern for more than the sense of sight. A patient's experience of a space comprises a comprehensive sensory bombardment and, therefore, acknowledging the senses of touch, hearing and smell, as well as sight, is a hallmark of considerate health care architecture.

Womersley primarily concerned himself with the patient's sense of sight. He ensured that the patient had views of the outside through use of floor-to-ceiling glass panels between the patient's room, the visitors' corridor and the external wall to reduce the sensation of being imprisoned (Johnston 1968, 157). The architect also took significant care with the lighting, both natural and artificial. In Scotland, the angle of the sun is extremely low in winter, and so, understanding the need to prevent glare within patient rooms, Womersley designed windows with overhangs to provide shade (Progressive Architecture 1968, 112). However, these overhangs were described in purely aesthetic terms elsewhere by the architect (Womersley 1969), suggesting the intentions behind the design were not entirely patient focused. Artificial lighting within the building was described in a 1968 Architectural Design article as being designed to 'facilitate both use and function of the building' with the architect rejecting uniform lighting in favour of localized lighting (Johnston 1968, 160). Task-specific and adjustable lighting is a theme that is very present in modern health care design; however, once again, Womersley also described the lighting as highlighting design details and dramatizing the structure of the facility rather than in terms of function or patient experience (Womersley 1969). When designing complex treatment facilities or large urban hospitals, architects generally focussed on designing for medical technologies and efficiency over the experience of a patient. However, there were attempts to provide guidelines for architects for appropriate lighting, acoustics and colours in health facilities including a long, if limited, report produced by the Nuffield Foundation in 1955 (Nuffield Trust and University of Bristol 1955). It is unknown whether Womersley or his medical advisors read this report. Given who produced it, it seems probable they would have known of it. Perhaps, the burden of the procedural requirements of the space was just too much.

It cannot be denied that the Nuffield Unit was an exemplary medical instrument in the early years of organ transplantation. The building design facilitated its medical performance and one could argue that Womersley's emphasis on the appearance of the facility was justified as he was attempting to reduce the feeling of institutionalization as much as possible. He wanted the Unit to feel like a hotel more than a medical facility (Womersley 1969).

In contrast, the extent to which Aalto and Jarvis considered the holistic bodily experience of the patient is very similar, and dramatically different to Womersley. Aalto's concern for a humane design, focussed on the emotional and

psychological experience of human beings in the built environment, was borne from multiple factors including the understanding that in the rebuilding of Europe after a period of extreme inhumanity (First World War), people needed and wanted more sensitive and symbolic architecture. It is evidenced by the way he designed almost everything within the Sanatorium with all of the patient's senses in mind. The lighting fixtures were designed and positioned to enable the patient to enjoy light over their bed without experiencing glare or disturbing the other patient in the room. This careful consideration of the patient experience (Aalto explained that the bedrooms, including lighting and colour schemes, were designed around a 'patient lying down' [Schildt 1994a]) demonstrates a belief in the impact of the built environment on the human being. The reading lights for the patient rooms can be clipped to the headboard of the bed or the bedside table while an overhead light was positioned above each bed as far out of the patient's natural line of sight as possible. Lighting was carefully considered for both MSKBR and MSKWH with a great deal of time taken to find the right temperature and colour for the artificial lighting. In the years between the two projects, a new technology came on the market. At MSKWH, LED lighting fixtures were used that were not available for MSKBR. These allowed EwingCole to provide lighting that mimicked the wave length and warmth of natural sunlight. This is an example of technology advancing to a point where previously known concepts can be implemented in a more comprehensive manner. The potential benefits of natural light were understood but only recently could it be faithfully replicated with artificial light.

EwingCole evidenced an attention to the individual needs of patients their designs for MSKBR and MSKWH. For example, MSKBR accommodates patients receiving chemotherapy in semi-enclosed booths but endeavoured to enable individual environmental adjustments through the installation of radiant heat panels above the infusion chairs which can be controlled independently. Eight years later, a change in preference for private rooms for chemotherapy infusion means that the room environment, including light and temperature, can be controlled to suit personal needs far more precisely than in the semi-open spaces within MSKBR. An aspect of environmental control that encouraged the move from booths to private rooms was that of acoustics. At MSKBR, the acoustics could not be adequately controlled, and it was felt privacy was compromised. Thus, at MSKWH, private rooms enable a more complete control of the patient experience. It is interesting to note that one of the reasons behind the shared bedrooms at Paimio was to ensure patients enjoyed 'identical conditions' with respect to natural light, heat and ventilation (Shand 1933, 85), while at the Nuffield Unit a patient who received a transplant in 1967 remembered in 2001 how 'there was a microphone you could speak through, but everyone could hear your conversation!' (Farrell 2016). Today there is a greater focus on the individual needs and experience of a patient, and technology is available to achieve privacy and individuality.

Unlike MSKBR, where the designers used a natural material palette both internally and externally, MSKWH has a sleeker and more contemporary feel with large expanses of glass and steel details. This is partly down to understanding the subliminal association between modern surroundings and modern medical treatment requiring a new facility to look as contemporary as possible. It is a quality that has been highlighted in Aalto's Paimio Sanatorium with Schildt (1994b) commenting that the design 'heightens the patient's impression of being surrounded by the most advanced resources of modern medicine'. Modern surroundings convey the message that the patient will receive the most advanced medical treatment available. This attitude contrasts with many medical designers and practitioners in the first decades of the twentieth century who preferred to continue building health care facilities in Georgian or Victorian styles (Gainsborough 1932, 1305).

Although Aalto believed the two-patient rooms to be beneficial in some regards, he also acknowledged the issue of noise disturbance that could be generated by sharing a room. Thus, Aalto included several details in an effort to reduce disruption. First, and most famously, is the washbasin design. Aalto uniquely and specifically designed the Paimio washbasin (Figure 7) so that the water from the tap hit the ceramic of the basin at an angle that would create the least splash and therefore the least amount of noise. The meticulous design of the washbasin also played a secondary role in the routine of hygiene within the sanatorium. By elevating the simple wash basin to the status of 'high design', it symbolized the importance of hand washing in the ritual of good hygiene.

Further details designed to reduce noise and control acoustics within the facility included rubber door stops on thresholds devised to reduce the sound of a nurse's cart or food trolley entering the bedrooms. The use of rubber and other softer materials within the sanatorium also aided the reduction of noise travel. The architectural critic, Philip M. Shand, highlighted the use of too little 'soft' material in hospitals as the cause of the often 'brutal' acoustics in such health care facilities (Shand 1933, 87). Aalto was consciously attempting to prevent this problem from occurring in his design for Paimio.

The architects' differing attentions to the patient's complete sensory experience is another clear example of the cyclical pattern of value placed on the role of architecture in the healing environment over the past ninety years. The similarities between Jarvis and Aalto and the differences between them and Womersley, all of whom were designing advanced and specific medical facilities, convey the shifting dominance of the medical machine over architecture to the more complete collaboration we witness today.

Architect's relationship with the medical profession

The question of whether and to what extent the Architect of each case study consulted experts within the medical profession, and if they did whether they

Figure 7. Paimio non splash sink in patient room (Bernoully 2010).

respected the opinions presented, is important and a valuable tool for distinguishing the periods of health care design. As medical knowledge and treatment systems advanced through the twentieth century, it became increasingly necessary for architects to seek advice as well as detailed, technical information from medical professionals, researchers and environmental engineers.

A number of physicians were on the commissioning committee for Paimio and Aalto has been declared ahead of his time for consulting physicians during the design process (Anderson 2010). However, he also expressed a rather derisive attitude towards medics' appreciations for, or understandings of, the

importance of architecture in the health care setting stating, 'The idea, it is perhaps hardly necessary to add, was an architect's, not a doctor's. The doctors fail to understand it' (*The Lancet* 1933, 1230). Three decades later however, Womersley's design work for Nuffield was based on recent research conducted by a regional hospital board of architects and medical advisors (*The Lancet* 1933, 1229–1231) which was absolutely necessary given the function of the building and the complex technical requirements for ensuring its proper function. This is not to say however, that Aalto entirely dismissed the notion that he could benefit from the advice of medics, or that the physicians consulted for Nuffield perceived the architecture itself as exceedingly important beyond facilitating the proper functioning of asepsis measures. The scepticism changed sides. By the 1920s, the fact that contagious infections were caused by harmful pathogens was common knowledge and, therefore, the need for a tuberculosis sanatorium to adhere to particularly stringent hygiene control measures was understood as especially important. While the myth of tuberculosis being caused by unhygienic surroundings persisted (Ehrström, Jetsonen, and Lindh 2005), it was commonly acknowledged that a treatment facility must be as hygienic as possible to prevent the spread of infection between occupants. Thus, the issue of hygiene ran throughout the design of Paimio and affected decisions concerning everything from the shape of the skirting boards (curved at the join with the floor) to the material finishes of furniture and interiors. Dust accumulation was prevented as far as possible through the use of furniture that could be wiped clean, glass lampshades (Heikinheimo 2014) and specially designed built-in wardrobes which hung off the bedroom walls with a sizeable gap between the bottom of the cabinet and the floor. Aalto, with his architectural education and lack of extensive experience in medical facility design, could not have implemented this multitude of safety measures without significant consultation with medical staff regarding what constituted a comprehensively hygienic environment. An aspect of the design that Aalto and the medical experts agreed upon was the patients' requirement for daylight. It at least partly explains why the commissioning board felt it worthwhile to spend the extra money on such an unusual design. Aalto's design ability is what created such an innovative and highly functioning building (it has never ceased in its use as a health care facility) with an egalitarian attitude to provision of natural light, access to nature, and fresh air.

The highly technical and utterly original nature of the activity for which the Nuffield Unit was being designed resulted in Womersley being at the mercy of the knowledge and desires of the physicians and the financer, the Nuffield Foundation. Since the Second World War, the Foundation had performed multiple studies of laboratories and hospitals around the UK (Allen 1961). An unwavering faith in the power of medical technology was developing and the belief in the psychological influence of architecture on patient outcomes was faltering. Peter Womersley did not even have the liberty of designing the initial plan and programmatic layout – considered too important to be left to a mere architect to

design. Instead, it was developed by immunologists, surgeons and physicians and handed to him after he was commissioned for the project. This resulted in Womersley's input being decidedly limited with respect to functional arrangement. What he contributed as a designer was the architectural details that made the programmatic ambition of the medics a reality and the aesthetic ambition to render the building an architectural, as well as medical, icon. Womersley's question of what a building for the transplantation of human organs should look like (Building 1969, 216) belies a deeper concern with outward appearance than with functionality. The first images of the design published in *Architectural Design*, 1964, discussed the building primarily in terms of its external appearance and stylistic expression, limiting the function and programmatic arrangement to just a few lines (*Architectural Design* 1964, 156–163). Womersley's architectural skills enabled a series of processes to coherently function and beautified the design.

In contemporary health care design, the condition is an amalgamation of Aalto and Womersley's experiences. Throughout the design process for both MSK facilities, physicians, nurses and other staff, as well as patients, were consulted by EwingCole; full-scale prototypes of the chemotherapy infusion stations and other specialist programmatic elements were constructed for comment from future users of the spaces and the design was modified accordingly. Designing specifically for cancer care enabled EwingCole's team to consider the specific physical and psychological effects and pressures of the condition and resulted in contemporary and welcoming facilities. However, the relationship was more complex and nuanced than either of the twentieth-century architects experienced. Like Womersely, Jarvis and his team required input from the medical profession to ensure an efficiently functioning facility. The design team acknowledged that there were certain aspects of the design they could not confidently contribute and first-hand experience they did not have. For example, Jarvis knew that a consultant oncologist could provide more information regarding a patient's needs and experiences when in a consulting room than a designer could guess at, and he also knew that a nurse best understands the daily operational requirements of chemotherapy infusion. However, while there was deference to the medical profession in some aspects of the design, unlike Womersley, Jarvis' team had confidence in their abilities as designers to provide a degree of sophistication and level of patient experience that would have been unattainable without their contribution. The attitude of the client in this regard also demonstrates a respect for the architectural profession and an acknowledged importance of architecture within the health care setting which has gained significant traction in the last 15 years.

The extensive introduction of medical technology to the treatment facility over the course of the twentieth century has, to a certain extent, conquered the Architect's Ego, but as the tide turns and a wider understanding of the potential positive effects of the environment on healing and health care delivery is gained,

the medical profession is turning to the architect once more to find solutions within the health care setting. There is a rapidly growing comprehension that without a well-designed and positively impactful environment for all the wonderful medical achievements, they cannot perform at their full potential. Thus, the twenty-first-century health care architect is necessarily a specialist, with great respect for the knowledge and experience of the medical staff but also with a sense that they can make a real, measureable difference to the lives of patients and staff alike.

Conclusion

We tend to think buildings serve only two purposes: accommodation and expression; that they suit our practical purposes (of residential, commercial, or institutional life) and give us attractive (or ugly) things to look at. What we fail to consider often enough is that they also have an effect on our physical and psychological wellbeing. It is well known that 'sick building syndrome' stems from materials and elements of a building which can literally make us sick, but the opposite is also true: buildings can have curative effects or therapeutic outcomes.

This study has delineated the shifting weight of environmental design within the practice of medicine. Medical buildings not only house medical technology and expert personnel; they take part in the healing process too (or fail to). It is as if the building also does some doctoring and nursing. While it has been shown that this awareness is growing in the health care industry, and the importance of environmental design is being recognized not only by the architectural profession but also the medical and managerial branches of health care, it too often remains outside of the core discussions in the discipline of architecture. These ideas and the evidence relating to how a health care building impacts upon a person's healing or a nurse's work are applicable to every element of the built environment in which humans live, work, learn and play. This study has focussed on health care facilities and presented an arc of progress regarding knowledge application, awareness and research. This arc is only just beginning in other fields; offices, schools, and housing…

The argument put forward in this paper could be mistaken for claiming that architects and health care buildings have not fundamentally progressed or changed in their priorities since the first decades of the twentieth century. There have, however, been some essential developments which set the health care architecture of the twenty-first century apart from its predecessor. While Aalto was essentially making conjectures based on his observations and design philosophy (however accurate or appropriate they might have been), architects today have a growing body of research and guidelines to help support their design decisions. For example, the World Health Organization has guidelines on maximum background noise levels in hospitals and there have been well over 600

substantial studies that demonstrate how hospital design can influence medical outcomes. In a time when cost efficiency is of the utmost importance in all health care systems, it is easy to understand the need for high-quality research supporting the value of good architectural design. It is imperative that features discussed in this paper, so central to a patient's psychological and physiological wellbeing, are not readily value-engineered out of a design.

The most successful health care architecture performs a balancing act of creating an environment that invokes patient confidence in the medical treatment they are receiving, while simultaneously minimizing the dominance of medical technology and sense of institutionalization. Buildings can render medical knowledge or technology visible, perceivable and comprehensible and therefore act as a 'mediator'; calming fears, providing security, and making an extreme sense of hopelessness more bearable. Each case study evidences this ability to some extent. This is an extremely important quality for all elements of the built environment, but is especially important in a clinical setting: your body has failed you, chaos has ensued and is reigning supreme; a health facility (of any type) must re-establish the feeling of order over chaos, and human power over cruel nature (Noschic 2001).

It has been discussed how, as medical technologies have gained a more dominant role in the healing of the sick, the significance of architecture in the same role deteriorated. In 1928, when Aalto was designing the Paimio Tuberculosis Sanatorium, architecture was instrumental to enabling the implementation of the most current treatment regime. As advances in medicine were made, and the technologies and machineries of medical practice became larger and more pervasive, the perceived impact and benefits of architecture diminished. It has taken several decades to redress this imbalance and EwingCole's work for MSK represents some of the progress that has been made.

Tracing specific theories in health care architecture points towards the fact that these ideas are likely to become more diverse, more widely debated and more necessary as we continue to make strides in technology. Innovative technologies in environmental control, lighting and materials (not to mention developments in empirical research on the quantitative effects of all that has been discussed in this paper), will inevitably require further, even more nuanced consideration of the impact of the building on the body and mind. For too long now, buildings have been judged on two factors: function and aesthetics. We can no longer ignore this third, fundamental factor; that of making us healthier, happier and more productive. This factor must be included in the most basic aims for any new design. The aspiration for any building must be more than to simply 'do no harm'.

Acknowledgment

Thanks must go to the Thouron Award, without its support this research could not have been completed.

Disclosure statement

No potential conflict of interest was reported by the authors.

Notes on contributors

Sophie Crocker works in Shanghai as a health care architect and medical planner. After studying Architectural Design at the University of Edinburgh, she gained a Masters in Architectural History and Theory from the University of Pennsylvania focusing on the history of perceptions of health in the built environment in the twentieth century.

David Leatherbarrow supervises research and directs the Ph.D. program in the Architecture Department of the University of Pennsylvania. He has taught theory and design at the Polytechnic of Central London and University of Cambridge and maintains a private practice with Lauren Leatherbarrow. His books include: Topographical Stories, Uncommon Ground, Roots of Architectural Invention, On Weathering: The Life of Buildings in Time, and Masterpieces of Architectural Drawing.

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